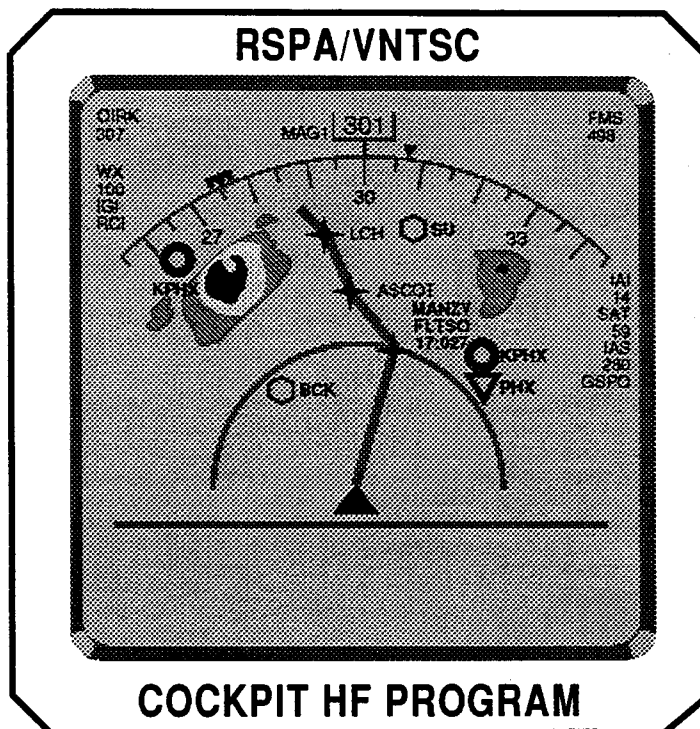


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Design of Instrument Approach Procedure Charts: Comprehension Speed of Missed Approach Instructions Coded in Text or Icons



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16. Abstract Instrument approach procedure (IAP) charts are often cluttered and confusing. The quantified effects of chart design changes on information transfer are needed by chart manufacturers to make changes which will enhance information transfer and human performance. The present study was conducted as part of a continuing effort at the Volpe National Transportation Systems Center Human Performance Laboratory to develop human performance-based design guidelines for IAP charts. The objectives of this experiment were to determine whether encoding missed approach instructions in text or icons would result in more efficient information transfer, and if the information transfer efficiency for either coding technique was dependent upon the level of information content. Twelve pilots currently licensed for instrument (IFR) flight participated as subjects. Text instructions were either taken directly or developed from instructions found on National Ocean Service (NOS) IAP charts. Because of formatting inconsistencies in current NOS missed approach instructions, a standard format was developed. In order to approximate the range of information content found in current NOS missed approach instructions, these instructions possessed one of three levels of information content: low, medium, and high. Comprehension speed was measured by counting the number of one second presentations (glances) subjects required to view the instructions in order to verbally report them. Report accuracy was also measured. Subjects completed questionnaires concerning their flight experience, preferences for IAP chart manufacturers, and preference for text or iconic coding of the instructions. Across the range of information content levels, iconic missed approach instructions were comprehended more quickly and as accurately as instructions coded in text of the font style and size used by NOS. Regardless of coding technique, report accuracy was significantly worse for instructions with a high information content level. Subjects indicated a strong preference for using iconic missed approach instructions in single pilot IFR conditions.			
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Preface

This report describes an experiment which examined the effects of encoding missed approach instructions in text or icons on pilots' comprehension speed and accuracy. Twelve pilots currently licensed for instrument (IFR) flight participated as subjects. Iconic missed approach instructions were comprehended more quickly and as accurately as instructions coded in text. Subjects indicated a strong preference for using iconic missed approach instructions in single pilot IFR conditions.

The study was conducted as part of a continuing effort at the Volpe National Transportation Systems Center to develop human performance-based design guidelines for instrument approach procedure charts. This report was prepared for the Aviation Research and Development Office of the Federal Aviation Administration.

The report was prepared by the Operator Performance and Safety Analysis Division of the Office of Research and Analysis at the Volpe Center, and was completed under the direction of M. Stephen Huntley, Jr., Volpe Center Cockpit Human Factors Program Manager. The research and report preparation were the responsibility of David W. Osborne, EG&G Dynatrend.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in.) = 2.5 centimeters (cm)
 1 foot (ft) = 30 centimeters (cm)
 1 yard (yd) = 0.9 meter (m)
 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
 1 acre = 0.4 hectares (he) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
 1 pound (lb) = .45 kilogram (kg)
 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
 1 tablespoon (tbsp) = 15 milliliters (ml)
 1 fluid ounce (fl oz) = 30 milliliters (ml)
 1 cup (c) = 0.24 liter (l)
 1 pint (pt) = 0.47 liter (l)
 1 quart (qt) = 0.96 liter (l)
 1 gallon (gal) = 3.8 liters (l)
 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$[(x - 32) (5/9)]^{\circ}\text{F} = y^{\circ}\text{C}$

METRICTO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
 1 centimeter (cm) = 0.4 inch (in)
 1 meter (m) = 3.3 feet (ft)
 1 meter (m) = 1.1 yards (yd)
 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
 1 square kilometer (kn²) = 0.4 square mile (sq mi, mi²)
 1 hectare (he) = 10,000 square meters (m²) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
 1 kilogram (kg) = 2.2 pounds (lb)
 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

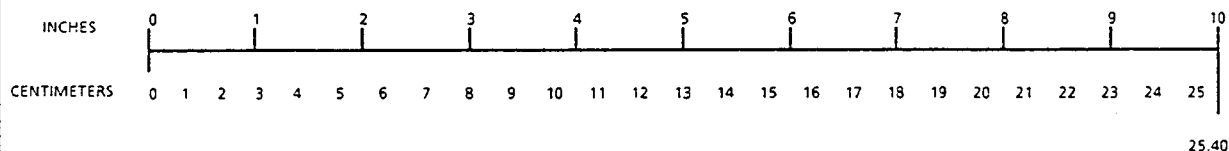
VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
 1 liter (l) = 2.1 pints (pt)
 1 liter (l) = 1.06 quarts (qt)
 1 liter (l) = 0.26 gallon (gal)
 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

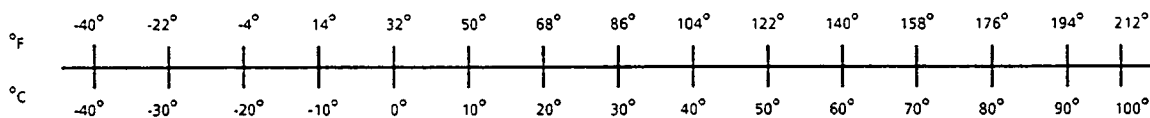
TEMPERATURE (EXACT)

$[(9/5)y + 32]^{\circ}\text{C} = x^{\circ}\text{F}$

QUICK INCH-CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION



For more exact and/or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price \$2.50. SD Catalog No. C13 10286.

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EXECUTIVE SUMMARY

Instrument approach procedure (IAP) charts are often cluttered and confusing. Additionally, the workload imposed by terminal operations can reduce the information processing resources available to the pilot for interpreting IAP charts, increasing the difficulty of chart interpretation. Specific deficiencies in the design of IAP charts have been identified, however, the quantified effects of chart design changes on information transfer are needed by chart manufacturers to make changes which will enhance information transfer and human performance.

In response to this requirement, the Federal Aviation Administration (1990) incorporated the investigation of human performance as a function of IAP chart design into their National [Research] Plan for Aviation Human Factors. The present study was conducted as part of a continuing effort at the Volpe National Transportation Systems Center Human Performance Laboratory to develop human performance-based design guidelines for IAP charts.

The objectives of this experiment were to determine whether encoding missed approach instructions in text or icons would result in more efficient information transfer, and if the information transfer efficiency for either coding technique was dependent upon the level of information content.

Twelve pilots currently licensed for instrument (IFR) flight participated as subjects. Text instructions were either taken directly or developed from instructions found on National Ocean Service (NOS) IAP charts. Because of formatting inconsistencies in current NOS missed approach instructions, a standard format was developed. In order to approximate the range of information content found in current NOS missed approach instructions, these instructions possessed one of three levels of information content: low, medium, and high.

Comprehension speed was measured by counting the number of one second presentations (glances) subjects required to view the instructions in order to verbally report them. Report accuracy was also measured. Subjects completed questionnaires concerning their flight experience, preferences for IAP chart manufacturers, and preference for text or iconic coding of the instructions.

Across the range of information content levels, iconic missed approach instructions were comprehended more quickly and as accurately as instructions coded in text of the font style and size used by NOS. Regardless of coding technique, report accuracy was significantly worse for instructions with a high information content level.

Subjects indicated a strong preference for using iconic missed approach instructions in single pilot IFR conditions. When subjects were asked which icons they would like to see changed to make them more clear, the most commonly chosen icons were those which incorporated radial information. The recommendations of these pilots were echoed by

members of the aeronautical charting committees of the Society of Automotive Engineers and the Air Line Transport Association after reviewing the design changes illustrated by the prototype IAP chart included as an appendix in this report.

Further research must be conducted before implementation of iconic missed approach instructions on NOS IAP charts can be recommended as a full replacement for the current text. In the interim, it is recommended that both text and icons be included on NOS IAP charts. The application of both coding techniques is illustrated in the prototype IAP chart.

1. INTRODUCTION

The International Civil Aviation Organization (ICAO) (1985) defines the purpose of instrument approach procedure (IAP) charts as providing "flight crews with information which will enable them to perform an approved instrument approach procedure to the runway of intended landing including the missed approach procedure and where applicable, associated holding patterns" (p. 24). In the United States, the largest manufacturers of IAP charts are the U.S. Department of Commerce National Ocean Service (NOS) and Jeppesen Sanderson. The instrument landing system (ILS) approach to runway 4 left at Newark International Airport is charted by NOS in Figure 1.

NOS organizes its IAP charts into six main sections (for an exhaustive listing and explanation of information in each chart section, refer to Federal Aviation Administration, 1968). While the content and general formatting standards and recommended practices for IAP charts are determined by organizations such as the ICAO and the Inter-Agency Cartographic Committee (IACC), specific formatting conventions and symbol sets are determined by the chart manufacturer.

Hansman and Mykityshyn (1990) have explained the determination of chart design as the result of responding to evolutionary pressures. Forces such as changes in standards and recommended practices originating from the ICAO, IACC, Federal Aviation Administration, and the National Transportation Safety Board, liability concerns of the chart manufacturer, and individual pilot feedback all combine to affect design changes. The input from professional organizations such as the Society of Automotive Engineers G-10 Aeronautical Charting Subcommittee, Air Line Pilots's Association, Aircraft Owners and Pilots Association, and the inertia imposed by initial design format could be added to this list.

Interpreting the complex and dense information on these charts can be challenging, particularly under poor cockpit lighting. In certain circumstances, this task must be accomplished while operating in the terminal area during periods of high pilot workload (Kantowitz & Casper, 1988). The workload imposed by terminal operations can reduce the information processing resources available for interpreting IAP charts, increasing the difficulty of chart interpretation. Relatively more complex approach procedures are accompanied by correspondingly more complex IAP charts, compounding the workload requirements.

Pilot feedback, as previously mentioned, and structured surveys such as that conducted by Cox and Connor (1987) have identified specific deficiencies in the design of IAP charts. However, the identification of design deficiencies is insufficient to improve system performance at the pilot-IAP chart interface. The quantified effects of chart design changes on information transfer are needed by chart manufacturers to make changes to the charts which will enhance human performance.

Not for Navigation

Top Margin

Amdt 10 91038

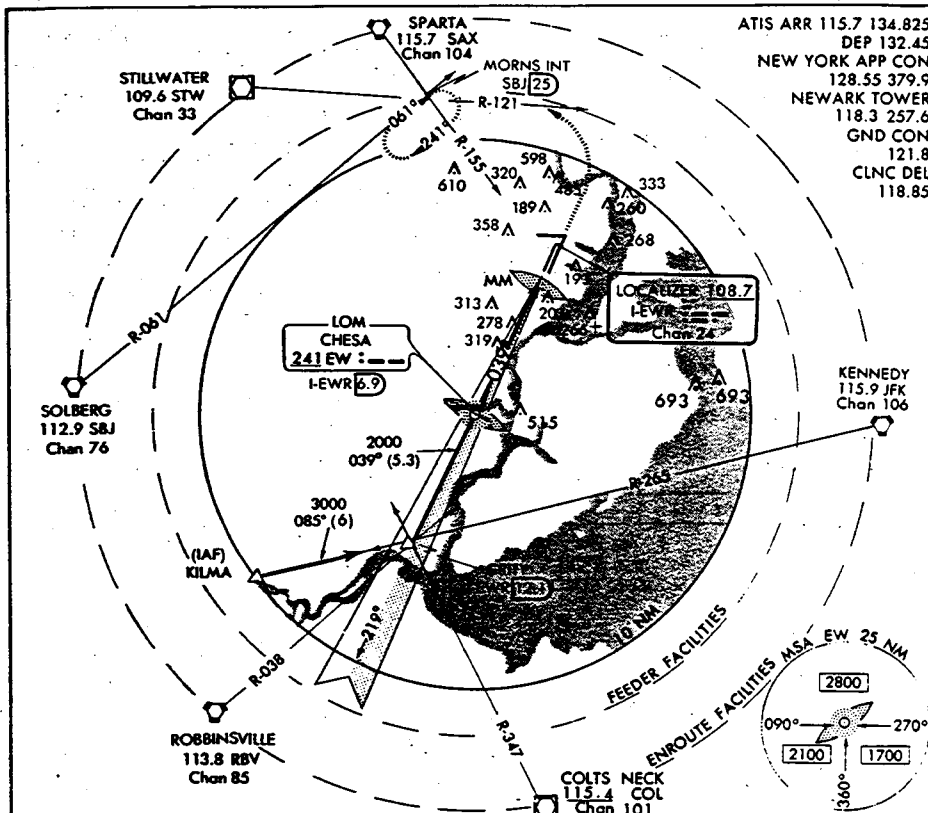
ILS RWY 4L

AL-285 (FAA)

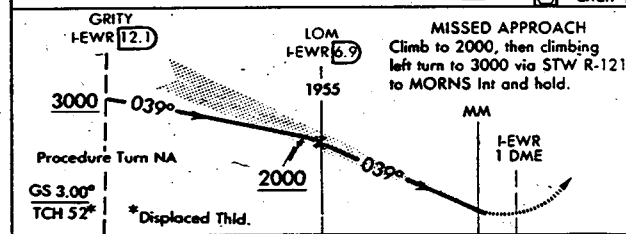
NEWARK INTL (EWR)
NEWARK, NEW JERSEY

ATIS ARR 115.7 134.825
DEP 132.45
NEW YORK APP CON
128.55 379.9
NEWARK TOWER
118.3 257.6
GND CON
121.8
CLNC DEL
118.85

Plan View



Profile View



Minimums

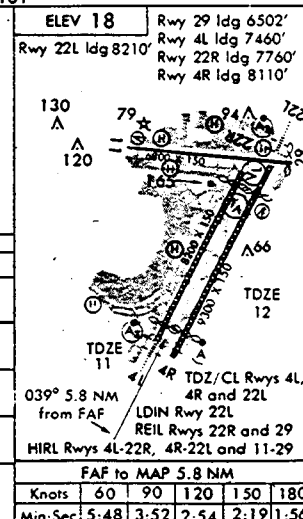
CATEGORY	A	B	C	D
S-ILS 4L	211/18 200 (200-1/2)			211/20 200 (200-1/2)
S-LOC 4L	580/24 569 (600-1/2)	580/50 569 (600-1)	580/60 569 (600-1 1/4)	
SIDESTEP RWY 4R	580/50 568 (600-1)			580-1 1/2 568 (600-1 1/2)
CIRCLING	660-1 642 (700-1)	660-1 1/4 642 (700-1 1/4)	920-3 902 (1000-3)	

ILS RWY 4L

40° 42' N-74° 10' W

NEWARK, NEW JERSEY
NEWARK INTL (EWR)

Airport Sketch



Bottom Margin

FIGURE 1. NATIONAL OCEAN SERVICE IAP CHART FOR THE ILS APPROACH TO RUNWAY 4 LEFT AT NEWARK INTERNATIONAL AIRPORT

Human performance-based design guidelines, empirically derived as a function of the information transfer characteristics of design alternatives, were not available to chart manufacturers prior to the study conducted by Multer, Warner, DiSario, and Huntley (1990). Recognizing this, the Federal Aviation Administration (1990) incorporated the investigation of human performance as a function of IAP chart design into their National [Research] Plan for Aviation Human Factors. The present study was conducted as part of a continuing effort at the Volpe National Transportation Systems Center Human Performance Laboratory to develop human performance-based design guidelines for IAP charts.

1.1 PRESENT RESEARCH ISSUES

The missed approach procedure is one of the most hazardous aspects of an instrument approach, and typically one in which pilots have the least experience. Pilots will execute a missed approach when, upon reaching the missed approach point, prevailing factors (e.g., visibility conditions, obstructions on the runway) preclude landing on the intended runway.

ICAO (1985) emphasizes the importance of clearly conveying the instructions for executing the missed approach procedure in their definition of the purpose of IAP charts. On NOS IAP charts, these instructions are displayed in the one of the upper corners of the *profile view* (see Figure 1). Although pilots should have memorized the missed approach procedures, it is not uncommon for them to be forgotten by the time they must be executed. Additionally, communicating with air traffic controllers may interfere with remembering the missed approach.

The missed approach instructions must be coded to allow the most efficient transfer of information possible because the number and complexity of tasks in terminal operations reduce pilots' spare attention. Stokes and Wickens (1988), and Stokes, Wickens, and Kite (1990) have compiled results of aviation human factors studies which have investigated the efficacy of depicting information pictorially. Almost exclusively, the application of pictures and icons has been restricted to conveying system status, rather than procedural directions. Research in displaying highway traffic sign messages provided the most relevant assessments of coding efficacy for procedural directions.

Dewar, Ells, and Mundy (1976) conducted a series of experiments comparing response times for subjects' verbal reports of traffic sign messages encoded in symbols or text. When the stimuli were large, text messages were identified faster than symbolic messages. However, this difference did not hold for small stimuli. No differences were found in the number of errors elicited by the coding techniques. Dewar, et al. postulated that although the response procedure was identical for both types of coding, it could be argued that the information processing requirements for vocalizing a clearly legible text message were substantially less than those for vocalizing symbols.

Therefore, in their re-examination of response time to traffic sign messages as a function of text or symbolic coding, Ells and Dewar (1979) employed a *same - different* judgement paradigm. Subjects responded to symbolic messages faster than text messages. The number of errors generated by both coding techniques did not differ. Whitaker and Stacey (1981) replicated the findings of Ells and Dewar (1979) in two experiments. Symbolic coding elicited faster response times, and coding techniques produced equivocal numbers of errors.

Based on the findings of Ells and Dewar (1979) and Whitaker and Stacey (1981), iconic encoding of missed approach instructions would be expected to result in faster comprehension without degrading accuracy. However, using icons to convey missed approach instructions would differ from their applications in these studies in several ways: the information content of a set of missed approach instructions is higher than that of a single highway traffic message; a sequence of activities need to be conveyed, rather than one activity; the instructions are given for movement in three dimensions rather than two; and, alphanumerics must be included with the icons (e.g., altitudes, headings, radials).

Given these differences, the consistent findings of Ells and Dewar (1979) and Whitaker and Stacey (1981) remain highly compelling and merit investigating the feasibility of iconic encoding of missed approach instructions.

1.2 OBJECTIVES AND HYPOTHESES

The objectives of this research were to determine whether encoding missed approach instructions in text or icons would result in more efficient information transfer, and if the information transfer efficiency for either coding technique was dependent upon the level of information content.

This experiment tested the following hypotheses:

- 1) Iconic encoding of missed approach instructions will elicit significantly faster information transfer across all information content levels.
- 2) Increasing the information content level of the instructions will degrade information transfer. This effect will be greater for instructions encoded in text than for those encoded in icons.
- 3) Coding techniques will not generate significantly different amounts of error.

2. METHOD

2.1 SUBJECTS

Twelve pilots (eleven males) currently licensed for instrument (IFR) flight and having at least 20/20 visual acuity (normal or corrected) participated as subjects (Ss) in this experiment. Subjects who were employees of the Volpe National Transportation Systems Center (VNTSC) were given an account number to which they charged their time, and Ss unaffiliated with VNTSC were paid \$50.00.

2.2 APPARATUS

Text instructions were either taken directly or developed from instructions found on NOS instrument approach procedure (IAP) charts. Because of formatting inconsistencies in current NOS missed approach instructions such as those shown in Table 1, a standard format was developed. All stimuli adhered to the standard formatting depicted in Table 2. Each set of instructions began with one of the entries in the box at the upper left corner, and ended with "and hold". Entries from the other boxes were selected to complete the instructions.

Text stimuli were created by using *WordPerfect* (Wordperfect Corporation) and *Ventura Publisher* (Xerox Corporation) installed on an IBM compatible 386 computer. All text stimuli (iconic stimuli also incorporated text) were printed in a 14 point Helvetica font closely matched to the font used by NOS for its IAP charts.

Iconic stimuli were created by using *DrawPerfect* (WordPerfect Corporation) installed on the same computer. Current NOS symbols were recreated, and new icons were developed, such as *climbing right turn to intercept "radial"* and *cross "radial"* as shown in Appendix D. All stimuli were printed using *Freedom of the Press* (Custom Applications Incorporated) post-script language interpreter installed on a Hewlett-Packard Laser Jet 3 with 300 dots per inch resolution. Printouts were reduced photographically and produced as pin-registered slides.

All slides were displayed at a contrast ratio of 11.88:1.91 candelas/meter² by adjusting the transmissivity of polarizing filters mounted on the tachistoscopic slide projectors' lenses. The contrast ratios were measured using a Soligor (Spot Sensor II) spot photometer and a calibration slide with the same darkness as the experimental slides.

Missed approach instructions possessed one of three levels of information content (low: 6 items; medium: 9 items, and high: 17 - 19 items), as determined by the procedure shown in Appendix A. These levels were chosen to approximate the range of information content found in current NOS missed approach instructions.

TABLE 1. EXAMPLES OF INCONSISTENT FORMATTING*

Page 14: "Climbing left turn to 2500 via 002 radial..."

Climbing left turn to 2500 via OSH R-002...

Page 184: "Climb to 2500 on BUU VOR R-221..."

Climb to 2500 via BUU R-221...

Page 222: "Climb to 2300 via R-225..."

Climb to 2300 via MTO R-225...

Page 226: "Climb to 2400 then right turn to 3200..."

Climb to 2400 then climbing right turn to 3200...

*Formatting inconsistencies in missed approach instructions found in *U.S. Terminal Procedures - East Central (EC) Volume 3 of 3*, Effective 19 September 1991. Actual entries are given above entries derived from the standard format depicted in Table 2.

TABLE 2. STANDARD FORMAT FOR CONSTRUCTING MISSED APPROACH INSTRUCTIONS (STIMULI)

<p>Climb to 10000</p> <p>Climbing left turn to 10000</p> <p>Climbing right turn to 10000</p> <p>Climb on heading 100° to 10000</p> <p>Climbing left turn on heading 100° to 10000</p> <p>Climbing right turn on heading 100° to 10000</p> <p>Climb via ABC R-100 to 10000</p> <p>Climbing left turn to intercept ABC R-100 to 10000</p> <p>Climbing right turn to intercept ABC R-100 to 10000</p>	<p>, then climbing left turn to 10000</p> <p>, then climbing right turn to 10000</p> <p>, then climb on heading 100° to 10000</p> <p>, then climbing left turn on heading 100° to 10000</p> <p>, then climbing right turn on heading 100° to 10000</p> <p>, then climb via ABC R-100 to 10000</p> <p>, then climbing left turn to intercept ABC R-100 to 10000</p> <p>, then climbing right turn to intercept ABC R-100 to 10000</p>
<p>, then left turn</p> <p>, then right turn</p> <p>, then left turn on heading 100°</p> <p>, then right turn on heading 100°</p> <p>, then left turn to intercept ABC R-100</p> <p>, then right turn to intercept ABC R-100</p>	<p>, then reverse course to the left</p> <p>, then reverse course to the right</p> <p>, then reverse course to the left climbing to 10000</p> <p>, then reverse course to the right climbing to 10000</p> <p>, then reverse course to the left climbing on heading 100° to 10000</p> <p>, then reverse course to the right climbing on heading 100° to 10000</p>
<p>, then climb on heading 100° to 10000 to intercept ABC R-100</p> <p>, then climbing left turn on heading 100° to 10000 to intercept ABC R-100</p> <p>, then climbing right turn on heading 100° to 10000 to intercept ABC R-100</p>	<p>, cross ABC R-100</p> <p>, cross ABC 10 DME</p>
	<p>direct ABC VOR</p> <p>direct ABC VOR/DME</p> <p>direct ABC VORTAC</p> <p>direct ABC NDB</p> <p>direct ABC NDB/DME</p> <p>direct Abcde LOM</p>
	<p>to ABC VOR</p> <p>to ABC VOR/DME</p> <p>to ABC VORTAC</p> <p>to ABC NDB</p> <p>to ABC NDB/DME</p> <p>to Abcde LOM</p> <p>to Abcde WPT</p> <p>to Abcde INT</p>
	<p>and hold</p>

A Gerbrands tachistoscopic projector system presented all stimuli and was controlled by a Solutions (IBM compatible 286) computer and by Ss using two pushbuttons (see Figure 2). Stimuli were projected at a size which allowed all alphanumerics to subtend the same visual angle as the alphanumerics in missed approach instructions on actual NOS IAP charts at the same viewing distance. To maintain a constant viewing distance of 20 inches from the Da-Lite 16.5 x 18 inch back projection screen, Ss placed their chins in a chin rest. Subjects' verbal reports were given to the experimenter (E) using a Realistic (model 33984 B) microphone and recorded on TDK (model D120 IECI/Type I) cassette tapes using a Marantz (model PMD420) cassette recorder.

Ambient room illumination was 4 footcandles at the subjects' eye point as measured by a Sylvania light meter (model DS-2050). Visual acuity was measured using a Graham-Field eye test chart (model 2867-1264).

2.3 PROCEDURE

After successfully completing visual acuity testing, each S was seated at a table and read an informed consent form summarizing the purpose and general procedures of the experiment (see Appendix B). Ss then completed a questionnaire concerning their flight experience and preferences for IAP chart manufacturers (see Appendix C). The order in which Ss were exposed to both coding techniques (text and iconic) was pseudorandomly counterbalanced. Subjects completed training and both practice and experimental trials for one coding technique before exposure to the other.

Training for the text and iconic instructions began with Ss studying the examples shown in Appendices D and E, respectively. Unlike the text instructions, Ss were required to learn a new "vocabulary" of icons. Subsequently, a self-test was provided to Ss which allowed them to assess their competency (see Appendix F). Examples depicted instructions of all information content conditions. Ss had as much time as they wished to study the instructions, and the E was available to answer questions. After completing the self-test on their own, the E reviewed the items in a pseudorandom order, and the Ss were required to demonstrate 100% accuracy in order to proceed.

Upon completion of training, Ss were seated in front of the projection screen. The E then adjusted the chin rest and introduced the response procedure. The procedure began with the display of a fixation point with the same contrast ratio as the instructions. Subjects pressed the *display* button to remove the fixation point and display the instruction slide for one second. The fixation point then returned. Subjects read the instructions and verbally reported them through their microphone to the E.

Subjects repeated this procedure until they believed that either they had reported the complete instruction correctly, or they had reported as well as they could and wished to proceed to the next instruction. Subjects then pressed the *carousel* button to prepare the

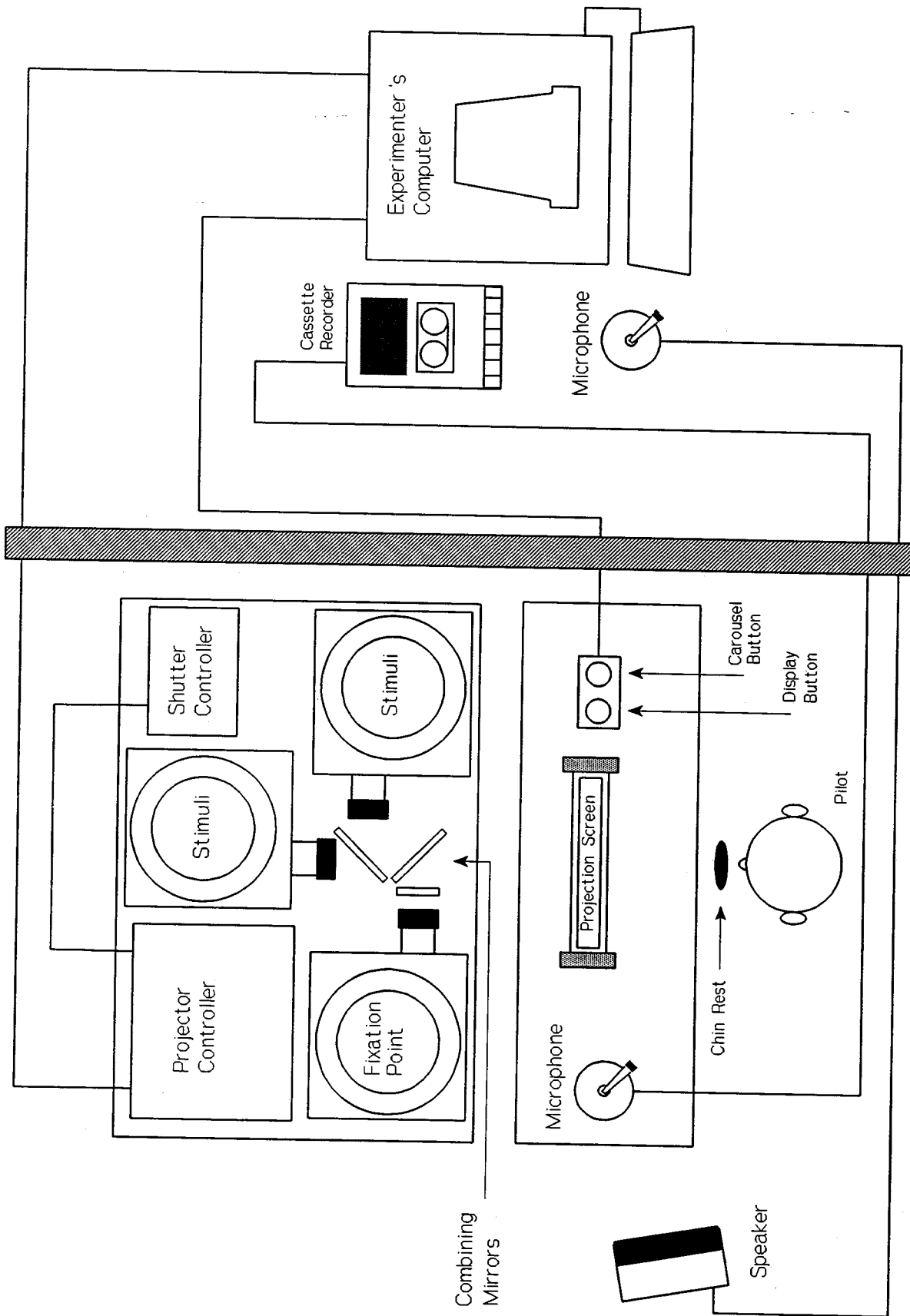


FIGURE 2. SCHEMATIC DIAGRAM OF THE EXPERIMENTAL APPARATUS

system for displaying the next instruction. The computer recorded the number of button presses for each instruction, and the E scored the Ss' reporting accuracy.

Subjects who performed the procedure correctly for the final 10 trials (trials 18-27) were judged as understanding the response procedure and were allowed to proceed to the experimental trials. Both during the practice trials and before the experimental trials began, the E verbally instructed Ss to minimize the number of stimulus presentations while reporting the instructions as accurately as possible.

In the practice trials, within each coding technique, the 27 instructions (three instruction information content sets - 9 instructions per set) were randomized in 3 blocks of 9 instructions, with each information content level appearing 3 times per block. Ss were exposed to the same 27 instructions in two forms, text and iconic, for a total of 54 practice trials.

During and after the practice trials, the E answered Ss' questions. After Ss had completed the practice trials, they indicated when they were ready to begin experimental trials. In the experimental trials, within each coding technique, the 90 instructions (three sets - 30 instructions per set) were randomized in 15 blocks of six instructions, with each information content level appearing twice per block. Ss were exposed to the same 90 instructions in two forms, text and iconic, for a total of 180 experimental trials.

After Ss had completed the second session of experimental trials, they completed the questionnaire shown in Appendix G. This questionnaire asked Ss for their subjective ratings of the coding techniques. They were also asked to recall difficulties they have encountered with IAP charts while flying to help identify other problem areas in chart design.

2.4 PERFORMANCE MEASURES

Dewar, et al. (1976) argued that using mean time to verbal report as a measure of comprehension speed for text and symbolic messages may have artificially inflated the response times for symbolic stimuli. In their experiments, accurate verbal reporting of symbolic stimuli required subjects to first comprehend a pictorial message and then convert the information into a verbal format. This conversion step was not necessary for verbally reporting text stimuli and may have inflated the mean time to verbally report symbolic stimuli. Therefore, the present study employed mean number of glances as a measure of comprehension speed. A glance was measured as one *display* button press, a measure which was independent of mean time to verbal report.

Report accuracy was measured as either correct (1) or incorrect (0). Because the correct execution of a missed approach instruction depends upon performing all steps in their proper order, errors resulting from misidentification or omission of information, or

transpositions in the perceived order of execution necessitated a binary report accuracy scoring system.

Both the mean number of glances and the mean report accuracy were computed for both coding techniques (text and iconic), and each information content level (low, medium, and high).

2.5 EXPERIMENTAL DESIGN

The experimental design is presented in Table 3. The within-subjects independent variables were coding technique (text and iconic), and information content level (low, medium, and high). Analyses of variance and the necessary post hoc tests were conducted on the data.

TABLE 3. EXPERIMENTAL DESIGN

Coding Technique	Text			Icon		
Information Content	Low	Medium	High	Low	Medium	High
Subjects S ₁ : S ₁₂						

3. RESULTS

3.1 PILOT FLIGHT EXPERIENCE AND IAP CHART USAGE

Subjects' ages ranged from 24 to 61 years, with a median age of 45.5 years. Total flight hours ranged from 330 to 21000 hours, with a median of 948.5 hours. The range of actual IFR flight hours was from 3 to 1750 hours, with a median of 62 hours. Simulated IFR flight hours (accomplished with foggles, a hood, or a flight simulator) ranged from 0 to 200 hours, with a median of 95.5 hours. Twelve, three, and one of the Ss had general aviation, Part 121, and Part 135 experience, respectively. Two Ss, including a helicopter pilot, had military flight experience.

All 12 Ss stated that they used NOS IAP charts, eight of which used them *always* or *frequently*. The Jeppesen-Sanderson IAP charts were used *always* or *frequently* by six Ss, while four other Ss *never* used them. Denoting their preference for either manufacturers' IAP charts by assigning each a rank of 1 (most preferred) or 2 (least preferred), the eight Ss who used both the Jeppesen-Sanderson and NOS IAP charts ranked them at 1.25 and 1.75, respectively. This difference was not significant ($p > .28$) as shown by the Binomial Test (Siegel, 1956).

3.2 MEAN GLANCES FOR CORRECT TRIALS

Table 4 presents the mean glances for correct trials (MG). The results of an analysis of variance (ANOVA) conducted on MG are summarized in Table 5. Both main effects, coding technique and information content level, were significant ($p < .05$).

The MG for iconic coding was significantly lower than that for text. All pairwise contrasts between MG for each information content level were then conducted with the Tukey-Kramer procedure (Kirk, 1982), and all were significant. From lowest to highest MG, the information content levels were: low, medium, and high. The MG data are depicted in Figure 3.

3.3 MEAN ERRORS

Table 6 presents the mean error (ME) data. Table 7 summarizes the results of an ANOVA conducted on ME. The main effect for information content level was significant ($p < .05$).

The Tukey-Kramer procedure (Kirk, 1982) was used to conduct all pairwise contrasts between ME for each information content level. The ME for the high information content level was significantly higher than those for both the low and medium levels. Figure 4 presents the ME data.

TABLE 4. MEAN GLANCES FOR CORRECT TRIALS

Coding	Information Content Level			Mean
	Low	Medium	High	
Text	2.18 (0.50)	3.58 (0.88)	6.55 (1.43)	4.09 (2.07)
Icon	1.62 (0.56)	2.81 (0.85)	5.63 (1.43)	3.32 (1.95)
Mean	1.90 (0.60)	3.20 (0.95)	6.09 (1.50)	

Note: Standard deviations are given in parentheses.

TABLE 5. Analysis of Variance for Mean Glances

Source	df	SS	MS	F
Coding	1	294.24	294.24	37.73*
Sub * Coding	11	85.78	7.80	
Info Level	2	6366.44	3183.22	559.05*
Sub * Info Level	22	125.26	5.69	
Coding * Info Level	2	11.31	5.66	3.27
Sub * Coding * Info Level	22	38.08	1.73	

* $p < .05$

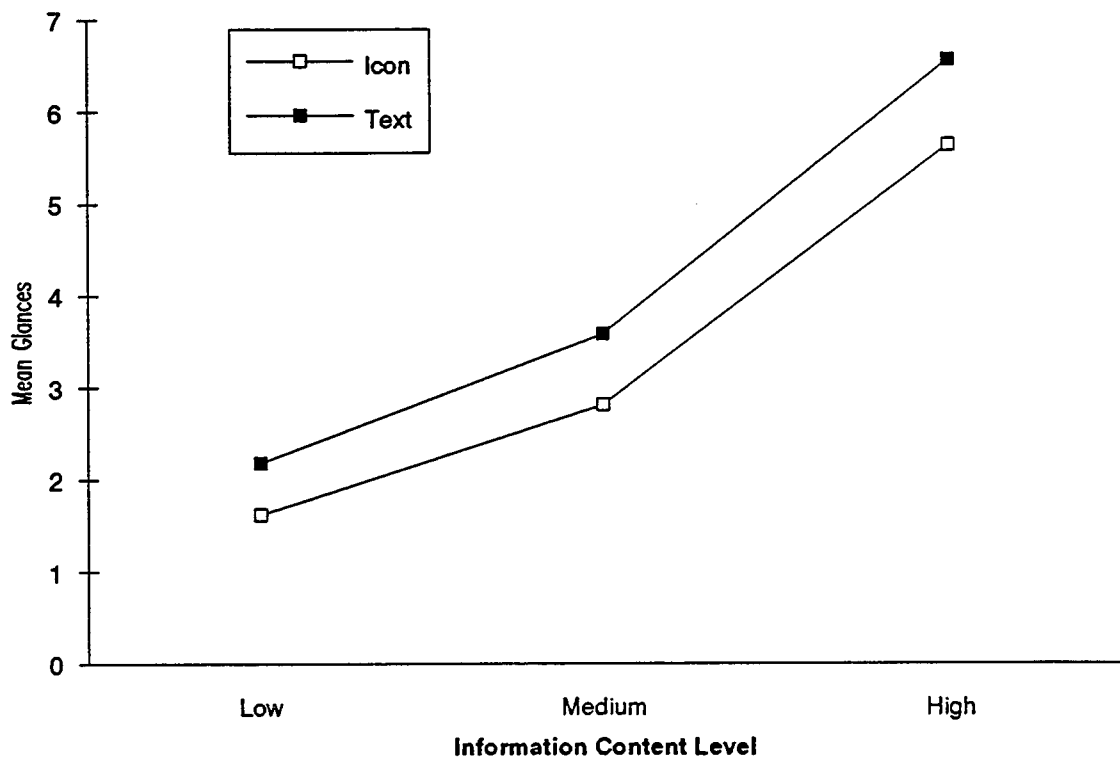


FIGURE 3. MEAN GLANCES FOR EACH CODING CONDITION IN EACH INFORMATION CONTENT LEVEL (CORRECT TRIALS ONLY)

TABLE 6. MEAN ERRORS

	Information Content Level			Mean
	Low	Medium	High	
Coding				
Text	0.02 (0.15)	0.01 (0.10)	0.03 (0.16)	0.02 (0.14)
Icon	0.01 (0.11)	0.02 (0.15)	0.05 (0.22)	0.03 (0.16)
Mean	0.02 (0.13)	0.02 (0.13)	0.04 (0.19)	

Note: Standard deviations are given in parentheses.

TABLE 7. ANALYSIS OF VARIANCE FOR MEAN ERRORS

Source	df	SS	MS	F
Coding	1	0.04	0.04	1.01
Sub * Coding	11	0.40	0.03	
Info Level	2	0.21	0.10	4.31*
Sub * Info Level	22	0.54	0.02	
Coding * Info Level	2	0.12	0.06	2.62
Sub * Coding * Info Level	22	0.49	0.02	

* $p < .05$

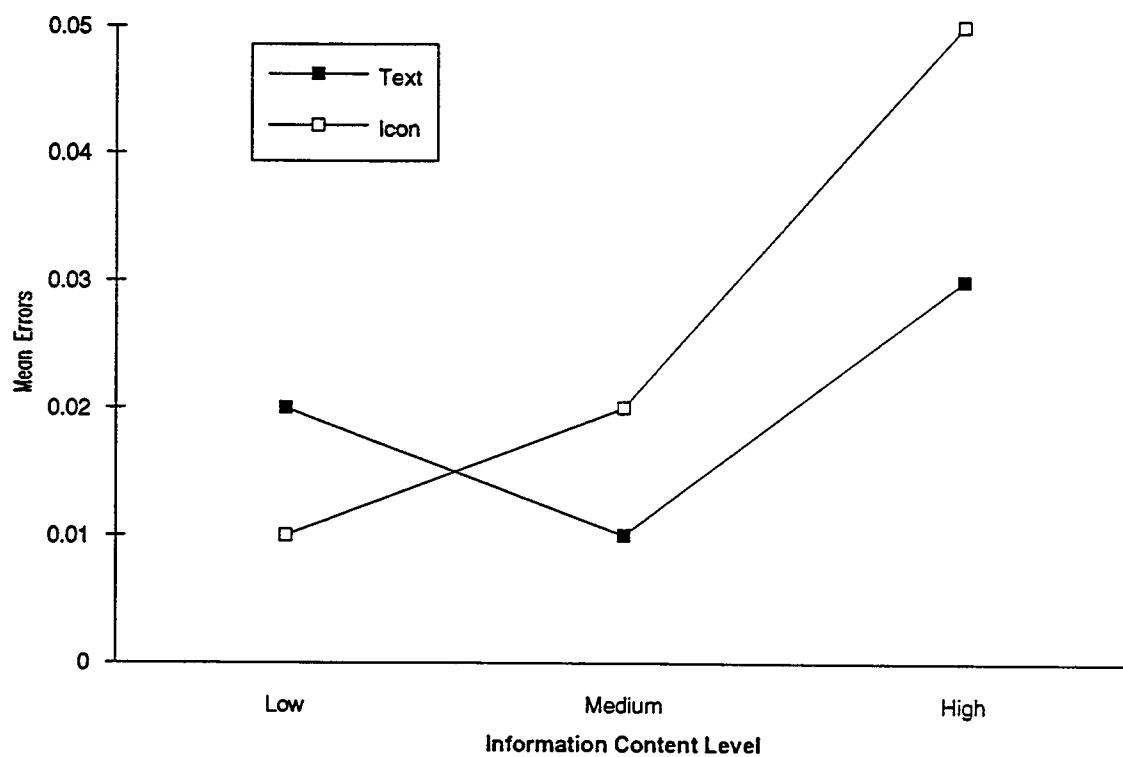


FIGURE 4. MEAN ERRORS FOR EACH CODING CONDITION IN EACH INFORMATION CONTENT LEVEL

3.4 QUESTIONNAIRE RESPONSES

A summary of the most frequent responses to the questionnaire items is presented in Appendix H. The highest concurrence of answers occurred for the first item. Eleven of the 12 pilots indicated that in single pilot IFR conditions, they would rather have the iconic than the text version of the missed approach instructions. The Binomial Test (Siegel, 1956) of this difference was significant ($p < .01$).

The most common reason given for this preference rating was that icons were perceived as being easier to comprehend, although they were more difficult to verbalize than text. Four subjects reported icons which incorporated radial information as being very difficult to read. Whether "read" in this case refers to "comprehend" and/or "verbalize" is unclear. Perhaps related to these comments were the statements of two Ss who reported that they would prefer the text version when flying in a two-person crew. Instructions conveyed in text may be easier to verbally brief to another crewmember in preparation of the approach.

Four items concerned problems the pilots had experienced with current missed approach instructions, and the IAP charts in general. The two most frequent responses were that the missed approach instructions were difficult to visualize and/or remember, and the relatively low contrast, small print was difficult to "find" (search for) and read while flying.

4. DISCUSSION

4.1 MEAN NUMBER OF GLANCES AND A PARADIGM BIAS

Subjects required significantly fewer glances to read and verbally report iconically coded instructions across all information content levels ($p < .05$). Mean number of glances (MG) for icons was expected to vary less than MG for text as a function of information content level, however, the coding technique * information content level interaction was not significant ($p > .05$).

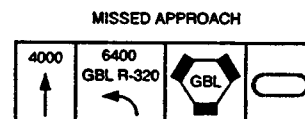
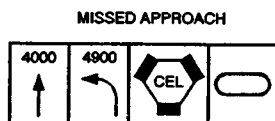
This differential effect was expected for two reasons. First, although a set of instructions coded in icons conveys the same information as when coded in text, iconic coding uses fewer figures and takes advantage of redundancies in relationships between instructions. For instance, the phrase "Climb to 4500', then climbing left turn to 4900' direct CEL VORTAC and hold." consists of 14 words, numerals, or alphanumeric identifiers, while the iconic version contains 7 figures, numerals, or alphanumeric identifiers (see Figure 5). Note that the absence of a radial between the second and third icons necessarily implies "direct", an example of how icons capitalized on redundant relationships between instructions.

Referring to the *Examples of Missed Approach Instructions* shown in Appendix E, the mean number of words, numerals, or alphanumeric identifiers in text instructions for low, medium, and high information content levels are 10, 12.8, and 27.2, respectively. The mean number of figures, numerals, or alphanumeric identifiers for the corresponding iconic instructions are 5, 6.6, and 11.8. Therefore, more information was expected to be conveyed per glance for icons than for text.

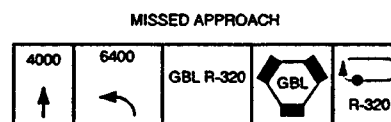
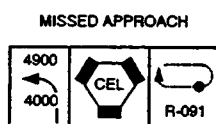
Second, icons integrated the instructions such that each step was more holistically conveyed. Each maneuver was boxed, and all information relevant to that maneuver was provided. The *breaking out* of each maneuver had already been accomplished. When reading text, pilots had to break out each discrete step themselves.

These two factors were expected to partially compensate for increases in information content for iconic instructions, producing correspondingly more divergent MG values between coding techniques. The data did not support this expectation. The absence of a differential effect for coding technique as a function of information content level may have been due to a bias in the experimental paradigm.

In order to verbally report iconic instructions, subjects were required to interpret and then translate the pictorial/alphanumeric information into words. Accurate interpretation of the icons was essential to subsequent translation into verbal reporting, whereas verbal reporting of text instructions did not require the translation step, nor did it even necessitate understanding the instructions to accurately verbally report them. This difference in information processing requirements was the rationale for using MG rather than mean time to verbal response (Dewar, et al., 1976) as the measure of comprehension speed. Inferring comprehension speed from measuring the number of



Icons of the design used in this experiment



Redesigned icons proposed by subjects and aeronautical charting committees

FIGURE 5. IDENTICAL MISSED APPROACH INSTRUCTIONS DEPICTED IN TWO VERSIONS OF ICONS

one second presentations subjects required to view the stimulus in order to report it was expected to circumvent the potential bias noted by Dewar, et al. However, the iconic - verbal translation step may have attenuated the amount of information conveyed during verbal reporting.

4.2 MEAN ERRORS

Of the 2160 verbal reports, 52 (2%) were inaccurate. When the errors were grouped according to type (e.g., left/right confusion, wrong altitude, omitted altitude) no systematic differences were found. Coding techniques did not elicit significantly ($p > .05$) different numbers of errors. Note that after a relatively brief period of training, subjects reported iconic instructions as accurately as instructions coded in text.

Regardless of coding technique, report accuracy was significantly worse for instructions with a high information content level ($p < .05$), as illustrated in Figure 4. All instructions were either taken directly or developed from instructions found on NOS IAP charts. In actual IAP charts, as the information content level of the instructions increases, the complexity of the information typically increases concurrently. The stimuli reflected this relationship. Whether the significant increase in errors is due to the greater amount of information and/or the accompanying increase in complexity is unknown.

4.3 REDESIGNING ICONS IN RESPONSE TO SUBJECT MATTER EXPERT REVIEWS

When Ss were asked which icons they would like to see changed to make them more clear, the most commonly chosen icons were those which incorporated radial information. Four Ss indicated that these icons were very difficult to read. They were not asked to articulate whether "read" in this case referred to "comprehend" and/or "verbalize". The recommendations of these pilots were echoed by members of the aeronautical charting committees of the Society of Automotive Engineers and the Air Line Transport Association after reviewing the design changes illustrated by the prototype IAP chart shown in Appendix I. This prototype also incorporates redesigns proposed by Multer, et al. (1990).

Recommended changes to particular missed approach instruction icons are depicted in both Appendix I and Figure 5. Arrows within icons instructing straight out climbs have been shortened. Previous icon combinations describing turns following climbs have been consolidated into a single icon. Radial icons have been broken out into two separate icons, conveying the maneuver first and then the radial. The missed approach holding pattern icon now uses an arrow to indicate the direction of turns, and provides the radial of the inbound leg. The location of the navigation aid relative to the pattern is indicated by a filled circle.

4.4 FOLLOW-ON RESEARCH WILL BE CONDUCTED

This experiment determined that iconic missed approach instructions were comprehended more quickly and as accurately as instructions coded in text, across a wide range of information content levels. However, further work must be accomplished before we fully understand the means by which icons facilitate information transfer.

Another experiment is currently being designed to answer the following questions:

- 1) Are the redesigned icons easier to interpret and/or verbalize than both their current cohorts and text?
- 2) Iconic instructions require a larger area for depiction than the text instructions. If the text was enlarged to occupy the same area as the icons, would comprehension speed for text improve?
- 3) Are instructions coded in text or icons more susceptible to interference from concurrent piloting tasks?

4.5 DESIGN RECOMMENDATIONS

The iconic missed approach instructions evaluated in this experiment were comprehended more quickly and as accurately as instructions coded in text of the font style and size used by NOS. Pilots indicated a strong preference for using icons in single pilot IFR conditions. However, further research must be conducted before implementation of iconic missed approach instructions on NOS IAP charts can be recommended as a full replacement for the current text.

In the interim, it is recommended that both text and icons be included on NOS IAP charts. The application of both coding techniques is illustrated in the prototype IAP chart (see Appendix I).

APPENDIX A

ASSESSMENT OF INFORMATION CONTENT LEVEL

Assessment of Information Content Level

Items which are underlined are considered to be discrete information elements.

<i>Instructions</i>	<i>Information Content</i>
MISSED APPROACH	
<u>Climbing right turn to 7000</u> <u>direct CTH VOR and hold.</u>	6 items
MISSED APPROACH	
<u>Climbing right turn to 2000</u> <u>direct NTL VORTAC and hold.</u>	6 items
MISSED APPROACH	
<u>Climb to 5000, then climbing right turn</u> <u>to 6000 direct NLV NDB/DME and hold.</u>	9 items
MISSED APPROACH	
<u>Climb via PEB R-347 to 9100</u> <u>to PEB VOR/DME and hold.</u>	9 items
MISSED APPROACH	
<u>Climb to 4000, then climbing left turn</u> <u>via ESI R-001 to 6400, then</u> <u>climbing left turn to intercept LNA</u> <u>R-320 to 8000 to LNA VORTAC</u> <u>and hold.</u>	18 items
MISSED APPROACH	
<u>Climb to 6100 direct ASN VORTAC,</u> <u>then climbing left turn to intercept</u> <u>ASN R-297 to 7100, then</u> <u>reverse course to the right</u> <u>climbing to 8900 direct ASN VORTAC</u> <u>and hold.</u>	19 items

APPENDIX B
INFORMED CONSENT FORM

Informed Consent Form

You have been asked to participate in the Missed Approach Instructions Study conducted by the Operator Performance Division of the Volpe National Transportation Systems Center (VNTSC).

The study's purpose is to assess the speed and accuracy with which pilots read missed approach instructions. If you agree to participate, you will be asked to press buttons which control a slide projector system which will briefly display missed approach instructions. You will then read and report those instructions over a microphone. You will also be asked to complete short questionnaires regarding your flight experience, instrument approach procedure chart use, and your impressions of the missed approach instructions used in this experiment.

The experiment will take approximately 2.5 hours to complete. There are no risks involved in participating in this study. Please do not hesitate to ask questions about the study at any time. Your data will be kept strictly confidential and your name will not be associated with your data.

Your participation in this study is strictly voluntary. If you agree to participate, you will either be given a VNTSC account number to which you may charge your time, or you will be paid \$50.00. You are free to withdraw at any time without penalty. Your cooperation is sincerely appreciated.

David W. Osborne, Ph.D.
Engineering Psychologist
EG&G Dynatrend
Volpe National Transportation Systems Center
(617) 494-3409

Signature and Age of Participant

Date

Name (please print)

Address and Phone Number

Signature of researcher

Date

APPENDIX C

FLIGHT EXPERIENCE AND IAP CHART PREFERENCE QUESTIONNAIRE

Pilot Experience

1. Age: _____ Gender: Male Female

2. Approximately, what is your:

total flight time _____ hours

total IFR flight time _____ hours

3. Please indicate the type of civil aviation experience you have:

Part 121 _____ Part 135 _____ General Aviation _____ Corporate _____

4. Do you have any military flight experience? Yes No

If yes: approximately what is your total military flight time? _____ hours

Please list the type(s) of aircraft flown: _____

5. Please rate the frequency with which you use the following instrument approach procedure charts:

	Always	Frequently	Sometimes	Rarely	Never
Jeppesen	1	2	3	4	5
NOAA	1	2	3	4	5
Other	1	2	3	4	5

Please specify *other*: _____

6. Please rank your preference for these manufacturers' instrument approach procedure charts (1 = most preferred, 3 = least preferred - if you do not use one of these types of charts, write "NA"):

Jeppesen _____

NOAA _____

Other _____

APPENDIX D

TRAINING MATERIAL FOR TEXT INSTRUCTIONS

Examples of Missed Approach Instructions

MISSED APPROACH
Climbing right turn to 7000
direct CTH VOR and hold.

MISSED APPROACH
Climb to 5000, then climbing
right turn to 6000 direct LNV
NDB/DME and hold.

MISSED APPROACH
Climb to 4000, then climbing left
turn via ESI R-001 to 6400, then
climbing left turn to intercept LNA
R-320 to 8000 to LNA VORTAC
and hold.

MISSED APPROACH
Climbing left turn to 3000
direct Grupp LOM and hold.

MISSED APPROACH
Climb to 4000, then climbing
left turn to 4900 direct AHE
VORTAC and hold.

MISSED APPROACH
Climb to 6100 direct ASN VORTAC,
then climbing left turn to intercept
ASN R-297 to 7100, then reverse
course to the right climbing to 8900
direct ASN VORTAC and hold.

MISSED APPROACH
Climbing right turn to 2000
direct NTL VORTAC and hold.

MISSED APPROACH
Climb via PEB R-347 to
9100 to PEB VOR/DME
and hold.

MISSED APPROACH
Climbing right turn on heading 227°
to 1000, cross NSR R-270, then
climbing right turn to intercept PMB
R-100 to 2800 to PMB VOR/DME
and hold.

MISSED APPROACH
Climbing left turn to 5000
direct Vikin WPT and hold.

MISSED APPROACH
Climb to 7900, then climbing
left turn to 8500 direct PNA
VOR/DME and hold.

MISSED APPROACH
Climb to 5200, then climbing right turn
to intercept FPC R-314 to 8200, cross
FPC 8 DME, then right turn direct GTS
VORTAC and hold.

MISSED APPROACH
Climbing right turn to 11200
direct ORN NDB and hold.

MISSED APPROACH
Climb via DNC R-024 to
8300 to DNC VOR and hold.

MISSED APPROACH
Climb to 11000 direct LCI VORTAC,
then climbing left turn to intercept
LCI R-073 to 12000, then reverse
course to the left direct LCI VORTAC
and hold.

APPENDIX E

TRAINING MATERIAL FOR ICONIC INSTRUCTIONS

Explanation of Iconic Missed Approach Instructions

Please do not turn to pages 8-10 until you have completed studying all previous pages.

These pages describe the pictorial depiction of missed approach instructions.

Page 2 is a review of standard NOAA chart symbols. The identifiers (e.g., PAR, PKN, Birdd) will always appear in the locations shown.

Pages 3 and 4 show symbols that we have developed. Their meanings are given to the right of each symbol.

In the *climb* and/or *turn* symbols, the direction of flight will always be presented on the bottom, any heading or radial information will be presented above the direction (arrow), and above that, the altitude to which you are climbing is shown. If you are already at the altitude shown, then maintain that altitude while performing the maneuver.

On page 4, please note the difference between the *turn to intercept (radial)* symbols and the *cross (radial)* symbols.

Pages 5 - 7 show examples of how these symbols are combined to form a set of missed approach instructions. The text version of these instructions is shown to the left of each set of instructions.

Please study pages 2 - 7 carefully until you feel comfortable with the symbol meanings and the "grammar" of the instruction sets. If you have any questions, please feel free to ask the researcher.

When you feel comfortable with the material, proceed to the self-test on pages 8 - 10. After interpreting the symbols, check your answer with the text under cover sheet. If you have forgotten or misinterpreted anything, please refer back to the previous material or ask the researcher for clarification. It is very important that you understand the symbols and can interpret the instructions accurately.

Navigational Aid Symbols



VOR



VOR/DME



VORTAC



Waypoint



Intersection



NDB



NDB/DME



LOM



DME



Missed Approach Holding Pattern

Climb and Reverse Course Symbols



Climb to 10000



Climbing left turn to 4000



Climbing right turn to 8000



Reverse course to the left climbing to 12000

(or, if you are already at 12000)

Reverse course to the left



Reverse course to the right climbing to 3000

(or, if you are already at 3000)

Reverse course to the right



Climb on heading 270° to 3000



Climbing left turn on heading 060° to 11000



Climbing right turn on heading 178° to 7000

Climb via Radial, Cross Radial, and Cross DME Symbols



Climb via ETL R-137 to 10500



Climbing left turn to intercept GLR R-344 to 3000

(or, if you are already at 3000)

Left turn to intercept GLR R-344



Climbing right turn to intercept FTI R-109 to 12000

(or, if you are already at 12000)

Right turn to intercept FTI R-109



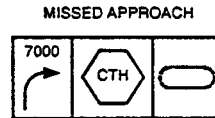
Cross SBA R-121 (you are already at 8000)



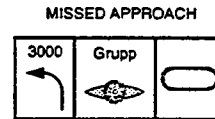
Cross Chief 8 DME

Examples of Missed Approach Instructions

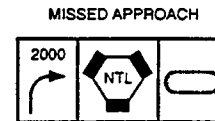
MISSED APPROACH
Climbing right turn to 7000
direct CTH VOR and hold.



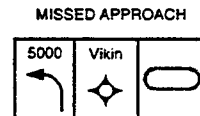
MISSED APPROACH
Climbing left turn to 3000
direct Grupp LOM and hold.



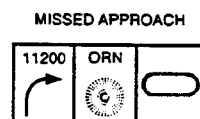
MISSED APPROACH
Climbing right turn to 2000
direct NTL VORTAC and hold.



MISSED APPROACH
Climbing left turn to 5000
direct Vikin WPT and hold.



MISSED APPROACH
Climbing right turn to 11200
direct ORN NDB and hold.

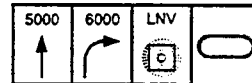


Examples of Missed Approach Instructions

MISSED APPROACH

Climb to 5000, then climbing right turn to 6000 direct LNV NDB/DME and hold.

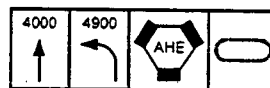
MISSED APPROACH



MISSED APPROACH

Climb to 4000, then climbing left turn to 4900 direct AHE VORTAC and hold.

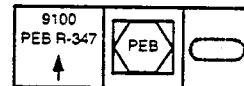
MISSED APPROACH



MISSED APPROACH

Climb via PEB R-347 to 9100 to PEB VOR/DME and hold.

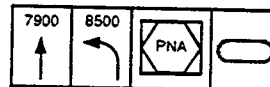
MISSED APPROACH



MISSED APPROACH

Climb to 7900, then climbing left turn to 8500 direct PNA VOR/DME and hold.

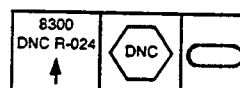
MISSED APPROACH



MISSED APPROACH

Climb via DNC R-024 to 8300 to DNC VOR and hold.

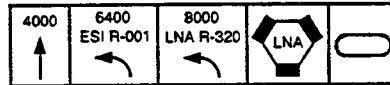
MISSED APPROACH



Examples of Missed Approach Instructions

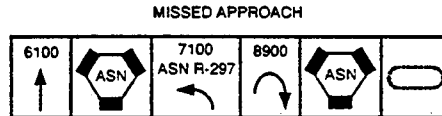
MISSED APPROACH

Climb to 4000, then climbing left turn to intercept ESI R-001 to 6400, then climbing left turn to intercept LNA R-320 to 8000 to LNA VORTAC and hold.



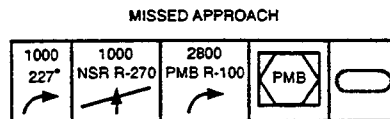
MISSED APPROACH

Climb to 6100 direct ASN VORTAC, then climbing left turn to intercept ASN R-297 to 7100, then reverse course to the right climbing to 8900 direct ASN VORTAC and hold.



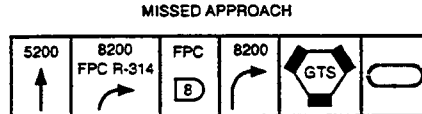
MISSED APPROACH

Climbing right turn on heading 227° to 1000, cross NSR R-270, then climbing right turn to intercept PMB R-100 to 2800 to PMB VOR/DME and hold.



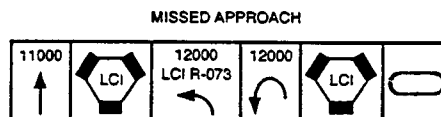
MISSED APPROACH

Climb to 5200, then climbing right turn to intercept FPC R-314 to 8200, cross FPC 8 DME, then right turn direct GTS VORTAC and hold.



MISSED APPROACH

Climb to 11000 direct LCI VORTAC, then climbing left turn to intercept LCI R-073 to 12000, then reverse course to the left direct LCI VORTAC and hold.



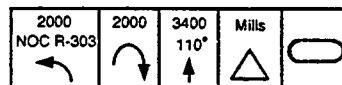
APPENDIX F

SELF-TEST FOR ICONIC INSTRUCTIONS

Missed Approach Instructions Self-Test

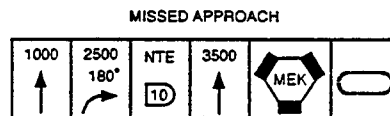
MISSED APPROACH

Climbing left turn to intercept NOC R-303 to 2000, then reverse course to the right climbing on heading 110° to 3400 to Mills Int and hold.



MISSED APPROACH

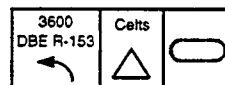
Climb to 1000, then climbing right turn on heading 180° to 2500, cross NTE 10 DME, then climb to 3500 direct MEK VORTAC and hold.



MISSED APPROACH

Climbing left turn to intercept DBE R-153 to 3600 to Celts Int and hold.

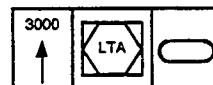
MISSED APPROACH



MISSED APPROACH

Climb to 3000 direct LTA VOR/DME and hold.

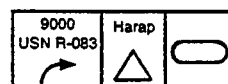
MISSED APPROACH



MISSED APPROACH

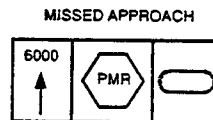
Climbing right turn to intercept USN R-083 to 9000 to Harap Int and hold.

MISSED APPROACH

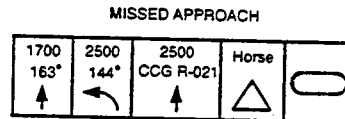


Missed Approach Instructions Self-Test

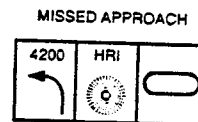
MISSED APPROACH
Climb to 6000 direct
PMR VOR and hold.



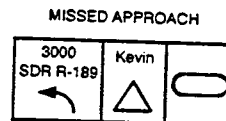
MISSED APPROACH
Climb on heading 163° to 1700, then
climbing left turn on heading 144°
to 2500 to intercept CCG R-021 to
Horse Int and hold.



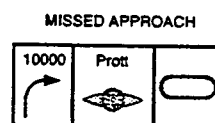
MISSED APPROACH
Climbing left turn to 4200
direct HRI NDB and hold.



MISSED APPROACH
Climbing left turn to intercept
SDR R-189 to 3000 to Kevin
Int and hold.

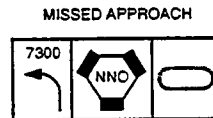


MISSED APPROACH
Climbing right turn to 10000
direct Prot LOM and hold.

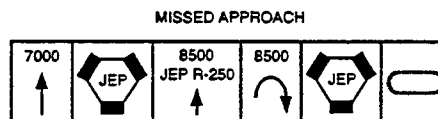


Missed Approach Instructions Self-Test

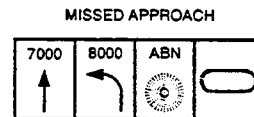
MISSED APPROACH
Climbing left turn to 7300
direct NNO VORTAC and hold.



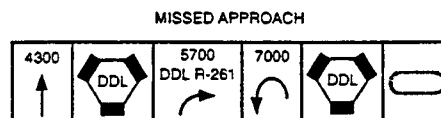
MISSED APPROACH
Climb to 7000 direct JEP VORTAC,
then climb via JEP R-250 to 8500,
then reverse course to the right direct
JEP VORTAC and hold.



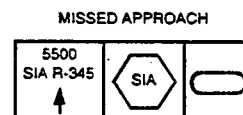
MISSED APPROACH
Climb to 7000, then climbing
left turn to 8000 direct ABN
NDB and hold.



MISSED APPROACH
Climb to 4300 direct DDL VORTAC,
then climbing right turn to intercept
DDL R-261 to 5700, then reverse
course to the left climbing to 7000
direct DDL VORTAC and hold.



MISSED APPROACH
Climb via SIA R-345 to
5500 to SIA VOR and hold.



APPENDIX G

SUBJECTIVE RATINGS QUESTIONNAIRE

Questionnaire

1. Please circle a number on each scale to show the difficulty of reading the instructions when they were displayed in:

text	1	2	3	4	5	6	7
very easy							
very difficult							

icons	1	2	3	4	5	6	7
	very easy						very difficult

Please explain your ratings: _____

2. In single pilot IFR conditions, would you rather have the text or iconic versions of the missed approach instructions to read?

Please circle one: text iconic Why? _____

3. Which icons would you change to make them more clear? How would you change them?

4. When you are flying, what problems do you encounter when reading missed approach instructions?

5. What other problems do you encounter when using instrument approach procedure charts?

6. What would you change on the instrument approach procedure charts to make them easier to use?

7. Do you write on or mark up your instrument approach procedure charts? If yes, please describe what you do and why.

APPENDIX H

MOST FREQUENT RESPONSES TO QUESTIONNAIRE ITEMS

Most Frequent Responses to Questionnaire Items

The most frequent responses to each questionnaire item are paraphrased below. The number of Ss giving a particular response is shown on the left.

Please explain your ratings of the difficulty of reading the instructions.

4 Icons were more easily comprehended but more difficult to verbalize than text.

In single pilot IFR conditions, would you rather have the text or iconic versions of the missed approach instructions to read?

3 Iconic was much easier to comprehend and comprehension was faster.

3 Iconic conveyed the individual steps of the procedure more clearly.

2 Would prefer the text with a two-person crew.

Which icons would you change to make them more clear? How would you change them?

4 The *radial icons* were very difficult to read.

When you are flying, what problems do you encounter when reading missed approach instructions?

6 The maneuvers are difficult to visualize and/or remember.

5 The text is difficult to find (or read).

2 I do not regularly brief the missed approach instructions.

What other problems do you encounter when using instrument approach procedure charts?

3 The NOS booklets are difficult to handle.

3 Small print is difficult to read.

What would you change on the instrument approach procedure charts to make them easier to use?

3 Increase the size and contrast of the print.

Do you write on or mark up your instrument approach procedure charts? If yes, please describe what you do and why.

7 I do not write on or mark up my IAP charts.

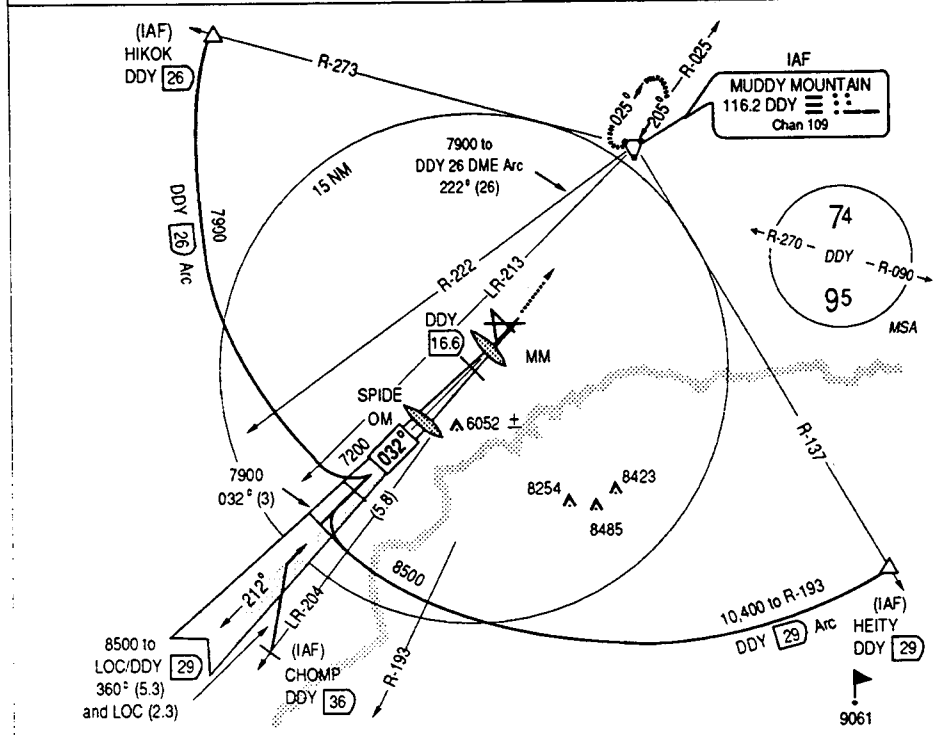
2 Only to indicate NOTAMs or other changes not reflected on the IAP charts.

APPENDIX I

VNTSC PROTOTYPE IAP CHART FOR ILS RWY 3 CASPER/NATRONA COUNTY INTL

VNTSC Prototype Chart - Not for Navigation

LOC I-SYD 111.3		APP COURSE 032°	FAF ALT 7200'	TDZE 5325'	CASPER, WYOMING CASPER/NATRONA COUNTY INTL (CPR)		
ATIS 126.15	CASPER APP CON 120.65	CASPER TOWER * 118.3 (CTAF)	GND CON 121.9	CASPER RADIO 122.4		CLNC DEL 121.9	
DME from DDY VOR. GS unusable MM inbound. Simultaneous reception of ISYD LOC and DDY DME required when radar unavailable. RADAR or DME required.				MISSED APPROACH: Climb to 7500' direct DDY VORTAC and hold. Apt. Elev 5348'			



Procedure
Turn NA

DDY 29

DDY 26

SPIDE
OM

7180

MISSED
APPROACH

7500

8500
GS 3.00°
TCH 50

032°

7900

7200

6060

DDY 16.6

MM

GS unusable
MM inbound.

CATEGORY

A

B

C

D

S-ILS 3

5525

- 1/2 200 (200 1/2)

S-LOC 3

6060 - 1/2 735 (800 1/2)

6060 - 1 1/2
735 (800 - 1 3/4)

6060 - 1 3/4
735 (800 - 1 3/4)

CIRCLING

6060 - 1 712 (800 - 1)

6060 - 2
712 (800 - 2)

6060 - 2 1/4
712 (800 - 2 1/4)

LOC/DME MINIMA

S-LOC-3*

5600 - 1/2 275 (300 1/2)

5600-3/4
275 (800 - 3/4)

CIRCLING

5780 1
432 (500-1)

5800 - 1
452 (500-1)

5800 - 1 1/2
452 (500 1 1/2)

5900 - 2
552 (600-2)

* CAT D visibility increased 1/4 mile for inoperative MALS.

REIL Rwy 21 and 26
HIRL Rwy 3-21 and 8-26

42° 54'N - 106° 28'W

FAF to MAP 5.5 NM

Knots	60	90	120	150	180
Min:Sec	5:30	3:40	2:45	2:12	1:50

Amdt 5 91150 AL-72 (FAA)

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